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Comparative Study of Pre-Operative IOL Power Calculation by IOL Master, Immersion and Non Immersion Techniques (A Scan, Manual Keratometer)

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Abstract: ***Cataract removal and artificial intraocular lens implantation is one of the most frequent and successful ophthalmic surgical procedures today. One of the remaining problems, however, is the accurate calculation of intraocular lens power necessary for attaining the desired postoperative refraction. Refractive outcome following phacoemulsification depends upon accuracy in multiple variables used in biometry technique. In this study I have compared the intraocular lens power calculation by conventional applanation ultrasound, conventional immersion ultrasound and partial coherence laser interferometry.***

Keywords: intraocular lens power calculation, IOL Master, keratometry, immersion technique and contact technique of axial length measurement. A-scan.

1. Introduction

Cataract removal and artificial intraocular lens implantation is one of the most frequent and successful ophthalmic surgical procedures today. One of the remaining problems, however, is the accurate calculation of intraocular lens power necessary for attaining the desired postoperative refraction.

Refractive outcome following phacoemulsification depends upon accuracy in multiple variables used in biometry technique. Individual contribution is as follows:

Variable in biometry	its attributable error in % in predicting post operative refraction following cataract surgery
Keratometry	54%
AC depth	8%
IOL power formula	38%
Quality of an IOL	Variable

Preoperative biometry of intraocular distances, especially the axial eye length, is the most critical step for an accurate calculation of the intraocular lens refractive power. A-scan ultrasonography is routinely used in ophthalmologic biometry. Recently a new technology has been included in a machine called IOL master which is claimed to be comparable to the time tested Ultrasound biometry.

But as always a new technology has to undergo multiple tests before it can take a place of gold standard test. There are many studies done and being done worldwide over the predictability of IOL Master (in comparison to the ultrasound biometry) for post operative refraction in cataract surgery. Mixed responses have been seen so far. The clinical accuracy of the axial eye length measurement using conventional ultrasound biometry has been reported to be approximately 100 to 120 mm. An axial eye length measurement error of 100 mm would result in a corresponding postoperative refractive error of 0.28 diopter.

2. Aims and Objectives

The purpose of the study was to compare 3 different methods of IOL power calculations [i.e. (1) conventional applanation ultrasound (2) conventional immersion ultrasound (3) partial coherence laser interferometry.] for the accuracy of intra ocular lens (IOL) power calculation and thereby to evaluate the predictability of each technique in terms of refractive outcome of patients undergoing cataract surgery .

3. Materials and Methods:

In this Prospective Randomized clinical trial, 75 patients undergoing phacoemulsification cataract surgery by same surgeon were randomized to undergo biometry with either A-scan applanation ultrasound, A-scan immersion ultrasound or partial coherence laser interferometry (optical biometry).

Patients were divided in three groups. Each group consisting of 25 patients.

1) 1st group of patients (n=25) underwent IOL power calculation by A-scan applanation ultrasound.
2) 2nd group of patients (n=25) underwent IOL power calculation by A-scan immersion ultrasound.
3) 3rd group of patients (n=25) underwent IOL power calculation by IOL master.

Confounding factor between two groups is axial length which is between 21-25 mm.

Patient Exclusion Criteria

- <40 or >80 years of age
- Mature cataracts, dense cataracts
- ANY MACULAR PATHOLOGY
- Retinal Detachment, Vitreous hemorrhages
- Corneal scars, tear film abnormalities
- Mentally challenged patients or
- patients with ocular Motility disorder
- AL more than 25 and less than 21 mm
- Prior history of refractive surgery in same eye.

The applanation A-scan, BIOMEDIX Echo RULE-2 was used for ultrasound biometry and the IOL MASTER (Zeiss Humprey Systems) was used for partial coherence laser interferometry. KERATOMETER based on BAUSCH & LOMB principle was used for corneal curvature measurements for patients in the ultrasound group. The patients consented and the preoperative biometry was performed. IOL calculations were carried out by the same person in both the groups.

The reliability of intraocular distance measurements was checked based on the sound to noise ratio (>2) in partial coherence laser interferometry and the retinal spikes in ultrasonography. The SRK-II formula was usd to calculate the IOL power in all the patients. The desired postoperative refraction, based on the pre-existing refractive error was decided prior to surgery.

The patient underwent phacoemulsification procedure through a 3.2 mm superior corneal tunnel and a foldable IOL was implanted. The patients were followed up on the postoperative day, 1 week, 3 week and at 6 weeks. The final post operative refractive outcome which was to be compared amongst different methods was taken at the end of 1.5 weeks. The postoperative refraction was carried out with an auto-refractor and confirmed by subjective refraction.

The postoperative mean spherical equivalent (MSE) was calculated for each of the patients and it was compared with the desired refraction. The MEAN NUMERICAL ERROR (MNE) and MEAN ABSOLUTE ERROR (MAE) were derived based on the difference between the predicted and attained postoperative refraction.

MAE defined as the mean of the absolute difference between the predicted and attained postoperative refraction. MAE defined as the mean of the absolute difference between the measured and the predicted postoperative spherical equivalent. The postoperative refraction outcome was compared between the groups that underwent biometry with ultrasound technique as opposed to partial coherence laser interferometry for statistical significance with independent sample T test.

4. Results

The mean age of the patients in the AUS group was 59.4+ 8.79 yrs (range 42–72 yrs) and 60.98 + 9.02 yrs (range 40-80 yrs) in the PCLI group. The mean preoperative axial length (AL) in the ultrasound group was 22.91 + 1.2 mm (range 21.01mm – 24.58mm) and 22.69 + 1.1 (range 21.14 mm – 24.36mm) in the PCLI group respectively. All the postoperative mean absolute error (MAE) was 0.86 dioptres in patients who underwent ultrasound biometry. The MAE in the PCLI group was 0.4775 D. There was no statistically significant difference between the groups in terms of postoperative refractive outcome (P = 0.19>0.05) 79% cent of the eyes in the ultrasound group achieved postoperative refraction of + 1 D of the predicted value as compared to 88% of patients in the PCLI group. When eyes with AL less than 21 and more than 25mm were compared in different sample of 20 patients, 10 pts of each group as described shows statistical significance with more precision in IOLM.

	ultrasound	IOL Master
Age	59.4	60.98
Range	42-72	40-80
Sex	Male-27/Female-31	Male-19/Female-31
AL mm	22.91	22.693
Post-Op. MAE	0.86	0.477
Post-Op. MNE	-0.40	-0.3175
P Value MAE	0.19	
P Value MNE	0.15	

5. Discussion

Our study compared the refractive outcome between applanation ultrasound, immersion ultrasound and partial coherence laser interferometry. All the groups compared favorably with no significant difference in functional outcome in the eyes with AL between 21-25 mm. However the patients who had partial coherence laser interferometry did better in reaching + 1 D of expected post operative refractive outcome.

Recent publications have reported mixed conclusions about which technology has a better predictive value. In a prospective study of 140 Wieg and found that both contact ultrasound biometry and the IOL master were similar in their predictive capabilities and concluded that the IOL master was easier to use. Rajan et al found that the use of optical biometry offered a better predictive value than the use of applanation axial biometry measurement. Haig is et al in their study of comparing the outcome of postoperative refraction measurement by two different method i.e. (Immersion ultrasound Vs PCLI) concluded that Post-operative refraction was predicted correctly within +/- 1.00 D in 85.7%.Both methods were comparable.

Simon Raymond et al. compared AUS with PCLI in their study, they concluded that calculation of IOL power based on ocular axial length measurement with PCI technology provided no clinical advantage over conventional applanation ultrasound as measured by post operative refractive outcome.PCI is unable to measure IOL power in up to 22% of patient because of dense cataracts, sub capsular opacities

or a signal noise ratio of <2:1.(PCI failures).Although many publications claim the IOL master to be superior to AUS in calculating IOL power, it is only by excluding those PCI failure, which are in significant numbers.(1 in 6 patient-17.6%).AUS is able to measure AL & give comparably good in all patient except those with silicone oil in vitreous. Wolfgang in his study concluded that Eye length determinate by PCLI were about 460µm longer than those measured with AUS.AL by IOLM is larger because : 1)No compression effect as seen in applanation method 2)distance between cornea and RPE was measured. 3) fovea is depressed than plane retinal surface Precision achieved by PCLI is 10 times better than AUS.MAE=0.49 by PCLI(c/c MAE AUS-0.67) –net improvement in predictability in terms of refractive outcome was 27%. Mark packer et al in his study concluded that

1) Immersion ultrasound is considered superior then applanation USG because there is
   - No corneal depression
   - Decrease in inter-individual variability
   - short learning curve
   - not limited by media opacity
2) Optical biometry useful in posterior staphyloma and intravitriol silicon oil

Restriction of my study:

1) To eliminate the confounding variable introduced by Keratometry performed with difficult technique on treatment groups, autokeratometry with IOL master should be performed.
2) Excluding PCI failure may cause serious bias & overestimate the clinical effectiveness of the outcome measure if an intention to treat analysis is not applied. This has been demonstrated in study by Simon Raymond et al. In my study only those patients have been included in whom PCLI could be done.
3) Effectiveness of IOL Master in unusual AL<21mm, >25mm can't be commented upon.
4) SRK-T formula was used in all patient for IOL power calculation, SRK-T may not be suitable for eyes with AL of <22(21-22mm) & >24(24-25mm) in my study. Holladay-2 may be the most suitable IOL power calculation formula for all range of AL.

6. Conclusions

Thus the duel beam partial coherence laser interferometry improves the predictive value of postoperative refraction in eyes undergoing cataract surgery. Also it is more precise in case of high myopes and hypermetropes as compared to A-scan biometry. It is less time consuming and has the advantages of improved precision and patient acceptability when compared to conventional applanation ultrasound biometry. But when there is a point of replacing the standard ultrasound technique with PCLI comes in to picture, the latter lags behind because it's a costly venture, PCLI failures are significant in numbers especially in a developing countries like India where still the majority patients have dense cataract at time of being operated for which precludes their biometry measurements by IOL Master.

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Abbreviations

IOL - Intra Ocular Lens
PCLI/PCI - Partial Coherence Laser Interferometry
IOLM - Intra Ocular Lens Master
A Scan - Amplitude Scan
MNE - Mean Numerical Error
MAE - Mean Numerical Error
SE - Spherical Equivalent
AL - axial length
ACD - anterior chamber depth
AUS - applanation ultrasound
IUS - immersion ultrasound

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